

1 CLAIMS

2 What is claimed is:

3 1. An apparatus for sending a heartbeat signal in cluster
4 computing system, the apparatus comprising:

5 a first host group; and

6 a first storage system associated with the first host
7 group, the first host group configured to selectively send a
8 heartbeat signal to a second host group by use of a network
9 coupled between the first host group and the second host group
10 or by use of a remote link coupled between the first storage
11 system and a second storage system associated with the second
12 host group.

13
14 2. A method of sending a heartbeat signal in a cluster
15 computing system, the method comprising:

16 generating a heartbeat signal from a first host group;

17 selectively sending the heartbeat signal from the first
18 host group to a second host group by use of a network coupled
19 between the first host group and the second host group or by use
20 of a remote link coupled between a first storage system
21 associated with the first host group and a second storage system
22 associated with the second host group.

1 3. An electronically-readable medium storing a program for
2 permitting a computer to perform method of sending a heartbeat
3 signal in a cluster computing system, the method comprising:
4 generating a heartbeat signal from a first host group;
5 selectively sending the heartbeat signal from the first
6 host group to a second host group by use of a network coupled
7 between the first host group and the second host group or by use
8 of a remote link coupled between a first storage system
9 associated with the first host group and a second storage system
10 associated with the second host group.

11
12 4. A program code embedded on a carrier wave for causing a
13 computer to perform a method of sending a heartbeat signal in a
14 cluster computing system, the method comprising:
15 generating a heartbeat signal from a first host group;
16 selectively sending the heartbeat signal from the first
17 host group to a second host group by use of a network coupled
18 between the first host group and the second host group or by use
19 of a remote link coupled between a first storage system
20 associated with the first host group and a second storage system
21 associated with the second host group.

22
23 5. An apparatus for receiving a heartbeat signal in cluster
24 computing system, the apparatus comprising:

1 a remote host group; and
2 a remote storage system associated with the remote host
3 group, the remote host group configured to selectively receive a
4 heartbeat signal from a network coupled with the remote host
5 group or by use of a remote link coupled to the remote storage
6 system.

7
8 6. A method of receiving a heartbeat signal in a cluster
9 computing system, the method comprising:

10 selectively receiving a heartbeat signal in a remote host
11 group by use of a network with the remote host group or by use
12 of a remote link coupled with a storage system associated with
13 the remote host group.

14
15 7. An electronically-readable medium storing a program for
16 permitting a computer to perform a method of receiving a
17 heartbeat signal in a cluster computing system, the method
18 comprising:

19 selectively receiving a heartbeat signal in a remote host
20 group by use of a network with the remote host group or by use
21 of a remote link coupled with a storage system associated with
22 the remote host group.

23

1 8. A program code embedded on a carrier wave for causing a
2 computer to perform a method of receiving a heartbeat signal in
3 a cluster computing system, the method comprising:

4 selectively receiving a heartbeat signal in a remote host
5 group by use of a network with the remote host group or by use
6 of a remote link coupled with a storage system associated with
7 the remote host group.

8
9 9. A cluster computing system, comprising:

10 a production host group;

11 a standby host group coupled to the production host group
12 by a network; and

13 a remote mirror coupled between the production host group
14 and the standby host group;

15 the production host group configured to selectively send a
16 heartbeat signal to the standby host group by use of at least
17 one of the network and the remote mirror.

18
19 10. A method of checking for failure in a cluster computing
20 system, the method comprising:

21 generating a heartbeat signal from a first host group;

22 selectively sending the heartbeat signal from the first

23 host group to a second to host group by use of a network coupled

1 between the host groups or a remote mirror coupled between the
2 host groups.

3
4 11. A cluster computing system, comprising:
5 a production host group;
6 a standby host group coupled to the production host group
7 by a network; and
8 a remote mirror coupled between the production host group
9 and the standby host group, the remote mirror including a
10 production site heartbeat storage volume (heartbeat PVOL) and a
11 standby site heartbeat storage volume (heartbeat SVOL) coupled
12 by a remote link to the heartbeat PVOL;

13 the production host group configured to selectively send a
14 heartbeat signal to the standby host group by use of at least
15 one of the network and the remote link.

16
17 12. The cluster computing system of claim 11 wherein the
18 production host group comprises a first heartbeat check module
19 configured to generate the heartbeat signal.

20
21 13. The cluster computing system of claim 11 wherein the
22 standby host group comprises a second heartbeat check module
23 configured to receive the heartbeat signal.

24

1 14. The cluster computing system of claim 11 wherein the
2 standby host group manages operations of the cluster computing
3 system if an invalid heartbeat signal is received by the standby
4 host group from the production host group.

5
6 15. The cluster computing system of claim 11 wherein the
7 heartbeat message comprises: a serial number assigned to the
8 heartbeat message, a time indicator indicating a time of the
9 generation of the heartbeat message, and an identifier
10 identifying a sender of the heartbeat message.

11
12 16. The cluster computing system of claim 11 further
13 comprising:

14 a second remote mirror coupled between the production host
15 group and the standby host group, the second remote mirror
16 including a second remote link for transmitting a heartbeat
17 signal;

18 the standby host group configured to selectively send a
19 heartbeat signal to the production host group by use of at least
20 one of the network and the second remote link.

21
22 17. A method of checking for failure in a cluster computing
23 system, the method comprising:

24 generating a heartbeat signal from a production host group;

1 selectively sending the heartbeat signal to the standby
2 host group from the production host group by use of at least one
3 of a network and a remote link; and

4 enabling the standby host group to manage operations of the
5 cluster computing system if an invalid heartbeat signal is
6 received by the standby host group from the production host
7 group.

8

9 18. The method of claim 17 further comprising:

10 selectively sending a heartbeat signal to the production
11 host group from the standby host group by use of at least one of
12 a network and a second remote link.

13

14 19. The method of claim 17 further comprising:

15 installing remote mirrors in the cluster computing system,
16 including:

17 registering a first storage volume to a device address
18 entry, the first storage volume located in a production site,
19 and, from the production site, changing a remote mirror that
20 includes the first storage volume into an enabled mode;

21 sending an activation message from the production site to a
22 standby site;

1 registering a second storage volume to the device address
2 entry, the second storage volume located in the standby site;
3 and

4 from the standby site, changing the remote mirror into an
5 enabled mode to install a remote mirror formed by the first
6 storage volume and second storage volume.

7
8 20. The method of claim 17 further comprising:

9 de-installing remote mirrors in the cluster computing
10 system, including:

11 from a production site, changing a remote mirror into a
12 disabled mode;

13 sending a de-activation message from the first production
14 site to a standby site; and

15 from the standby site, changing the remote mirror into a
16 disabled mode to de-install the remote mirror.

17
18 21. The method of claim 17 wherein the selectively sending step
19 comprises:

20 determining if a network between the production site host
21 and the standby site host is enabled;

22 if the network is enabled, sending a heartbeat message along
23 the network from the production site host to the standby site
24 host;

1 determining if a remote mirror between the production site
2 host and the standby site host is enabled; and
3 if the remote mirror is enabled, sending a heartbeat message
4 along the remote mirror from the production site host to the
5 standby site host.

6
7 22. The method of claim 17 further comprising:
8 receiving a heartbeat message from the production site host
9 to the standby site host in the cluster computing system,
10 including:

11 determining if a network between the production site host
12 and the standby site host is enabled;
13 if the network is enabled, checking for a heartbeat message
14 along the network from the production site host to the standby
15 site host;

16 determining if a remote mirror between the production site
17 host and the standby site host is enabled;

18 if the remote mirror is enabled, checking for a heartbeat
19 message along the remote mirror from the production site host to
20 the standby site host; and

21 if an invalid heartbeat is received along the network and
22 along the remote mirror, enabling the standby host to manage
23 operations of the cluster computing system.

24

1 23. A method of setting a heartbeat checking procedure between
2 a primary group and a secondary group in a cluster computing
3 system, the method comprising:
4 providing a request command that determines the heartbeat
5 checking procedure;
6 responsive to the request command, enabling a first
7 heartbeat check module in the primary group to activate or de-
8 activate a network between the primary group and the secondary
9 group;
10 responsive to the request command, enabling the first
11 heartbeat check module to activate or de-activate a remote
12 mirror between the primary group and the secondary group;
13 permitting the first heartbeat check module to send the
14 request command to a second heartbeat check module in the
15 secondary group;
16 responsive to the request command, enabling the second
17 heartbeat check module to activate or de-activate the network
18 between the primary group and the secondary group;
19 responsive to the request command, enabling the second
20 heartbeat check module to activate or de-activate the remote
21 mirror between the primary group and the secondary group;
22 if the second heartbeat check module has activated the
23 network, then checking for a heartbeat signal along the network;
24 and

1 if the second heartbeat check module has activated the
2 remote mirror, then checking for a heartbeat signal along the
3 remote mirror.

4
5 24. A method of failure notification in a cluster computing
6 system, the method comprising:

7 selectively activating a network between a primary group
8 and a secondary group;

9 selectively activating a remote mirror between the primary
10 group and the secondary group;

11 checking for a failure occurrence in the primary group;

12 if the network is activated, then sending a failure
13 notification message from the primary group to the secondary
14 group along the network;

15 if the remote mirror is activated, then sending a failure
16 notification message from the primary group to the secondary
17 group along the remote mirror; and

18 based upon the failure notification message, displaying in
19 the secondary group an indication of the failure occurrence.